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Visualizing Mean and Median: Utilizing PASTA Teaching Aids to Master Grouped Data in Mathematics

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A B S T R A K

Pengembangan media pembelajaran, seperti alat peraga, yang membantu siswa memahami rumus-rumus yang kompleks pada konsep statistika mean dan median data berkelompok sangat diperlukan dalam pembelajaran. Artikel ini bertujuan untuk mendeskripsikan penggunaan alat peraga matematika "PASTA" (Papan Statistik) dalam pembelajaran matematika. Peneliti menggunakan metode penelitian Research and Development dengan model pengembangan 4D yang meliputi tahap Define, Design, Development, dan Disseminate. Alat peraga ini dibuat dari bahan triplek dan akrilik. Tujuan Pasta adalah memperagakan prinsip kerja statistik pada data berkelompok, membantu siswa memahami dan menghitung nilai mean dan median pada data berkelompok, serta menciptakan suasana belajar matematika yang lebih menyenangkan. Hasil validasi ahli menunjukkan alat peraga PASTA dinilai layak untuk digunakan dalam pembelajaran. Hasil UAT menunjukkan dominasi respons positif dari pengguna, sehingga menggambarkan keberhasilan suatu alat peraga dalam pembelajaran. Dengan demikian, PASTA dapat digunakan sebagai media pembelajaran matematika yang efektif, khususnya untuk membantu siswa memahami konsep statistika secara lebih mendalam serta meningkatkan motivasi dan hasil belajar siswa.

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A B S T R A C T

The development of learning media, such as teaching aids, that help students understand complex formulas for the statistical concepts of the mean and median in grouped data is essential for learning. This article aims to describe the development of the mathematical teaching aid "PASTA" (Statistics Board) in mathematics learning. The researcher used the Research and Development method with a 4D development model comprising the

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Define, Design, Development, and Disseminate stages. This teaching aid is made of plywood and acrylic materials. The purpose of PASTA is to demonstrate the principles of statistics for grouped data, help students understand and calculate the mean and median of grouped data, and foster a more enjoyable learning environment in mathematics. The results of expert validation indicate that the PASTA teaching aid is suitable for learning. The UAT results show a strong positive response from users, indicating the teaching aid's success in learning. Thus, PASTA can be used as an effective medium for mathematics learning, especially in helping students understand statistical concepts more deeply and in increasing student motivation and learning outcomes.

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1. INTRODUCTION

Learning mathematics is not simply memorizing facts, rules, formulas, procedures, or algorithms. It is more than that, guiding students to understand and communicate abstract concepts so they can be clearly understood and used to solve related problems (Guncaga et al., 2019; Umami, 2024; Wathoni, 2024). Learning mathematics is not just about counting; it also involves developing precision, patience, problem-solving, reasoning, and communication skills, as well as other mathematical abilities, through a systematic, logical structure. The importance of learning mathematics indicates that the mathematics learning process needs to be well-planned, thorough, and effective for optimal implementation (Albina & Pratama, 2025).

To achieve optimal learning outcomes, mathematics learning in schools is directed towards students achieving the competencies outlined in the Learning Outcomes (CP) in mathematics (Bait et al., 2025). Therefore, mathematics learning activities themselves are not solely oriented toward mastering mathematical material. However, mathematics is often used as a tool to help students achieve these competencies (Sintia et al., 2024). Therefore, the scope of mathematics subjects studied in schools needs to be aligned with the competencies students must achieve. For example, in statistics, to enable students to understand statistical formulas rather than simply use them without understanding their meaning, learning that emphasizes these competencies is necessary.

The importance of learning mathematics and of creating sound, comprehensive mathematics instruction is at odds with the reality in the field. Mathematics is often perceived as a difficult and unappealing subject. Students also perceive statistics as a subject that emphasizes calculations and formula memorization at the beginning of their studies, which can lead to fear and a lack of interest in the subject (Veloo et al., 2018). This is also due to the excessive complexity of statistical formulas, especially when faced with grouped data. Furthermore, many students complain of confusion about the meaning of statistical formulas, as they tend to emphasize procedural mastery without understanding the formulas' meanings (Cook & Fukawa-Connelly, 2016; Selvi et al., 2026). Therefore, appropriate and enjoyable alternative statistical learning processes are needed to achieve optimal learning outcomes.

There are many things educators can do to create optimal learning, one of which is to provide students with appropriate learning media. Learning media is a crucial element of learning because it can help teachers explain a concept (Mukarromah & Andriana, 2022; Putri, 2023). Furthermore, learning media can also help students understand a concept easily and make learning more enjoyable (Putri, 2023).

More specifically, one type of learning media, such as teaching aids, can facilitate student understanding of a concept. Teaching aids are used by teachers and students to demonstrate learning related to specific material, engage students in understanding and communicating a concept, foster their creativity, and make mathematics learning more enjoyable (Mulianingtias et al., 2024). This aligns with several other studies that emphasize the importance of using teaching aids to motivate teachers and students in mathematics learning and to present abstract mathematical concepts in concrete terms, making them easier for students to grasp and comprehend (Rahayu et al., 2024; Wathoni, 2024). Therefore, teaching aids play a crucial role as aids in creating an effective teaching and learning process.

Based on the results of a literature review, researchers found studies discussing the development of statistical learning media, but these were limited to a single data (Saidah & Faizah, 2022). There are also studies using digital media such as videos or animations that do not emphasize active student involvement (Al-haddad et al., 2024). Research examining the development of statistical learning media that emphasizes the process of understanding

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statistical formulas is still limited. This is reflected in recommendations and emphasis from existing studies to conduct further research on the development of learning media, especially in statistical concepts (Apichatibutarapong, 2017). Consequently, research is needed to develop learning media that effectively require students to understand and communicate statistical concepts.

In this study, researchers developed a statistical teaching aid that is expected to help create optimal statistics learning. The PASTA teaching aid aims to demonstrate the principles of statistics for grouped data, assist students in calculating the mean and median of grouped data, and create a more enjoyable learning environment in mathematics. With this in mind, this study aims to develop learning media that can assist students in the learning process. Therefore, the authors conducted a study entitled "Visualizing Means and Medians: Utilizing PASTA Teaching Aids to Master Grouped Data in Mathematics."

2. METHOD

This research employed a Research and Development (R&D) method with a 4D development model encompassing the Define, Design, Development, and Disseminate stages. The design stage employed a Fishbone Diagram, as shown in Figure 1 below.

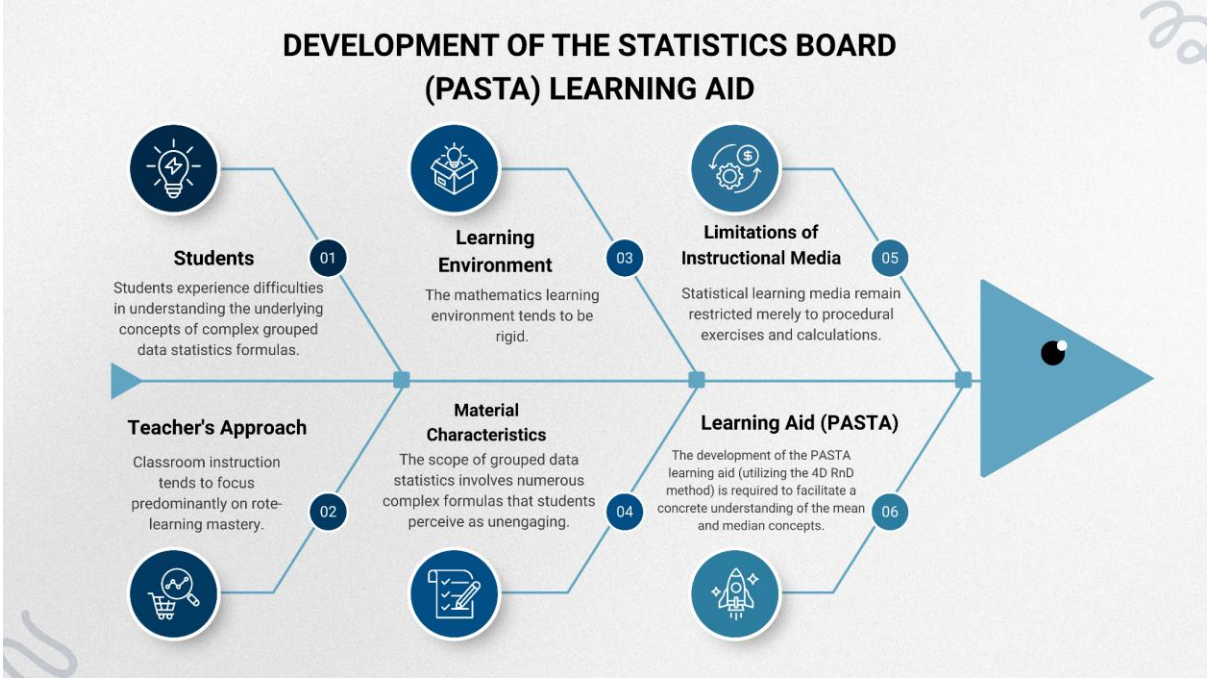

Figure 1. Fishbone Diagram

A more detailed explanation of Figure 1 will be discussed in the results and discussion section of the define stage.

In the design stage, the researcher conducted several activities: selecting appropriate materials and tools; creating an initial design for the learning media; compiling statistical materials and a plan for demonstrating the material using visual aids; and developing an Expert Validation Sheet and a User Acceptance Test (UAT). In the development stage, the researcher conducted several activities: developing the PASTA visual aids according to the design developed in the design stage, conducting expert validation involving two experts, namely a Mathematics Education lecturer and a mathematics teacher, and conducting a limited trial of the visual aids while distributing the UAT to 11 Mathematics Education students as the users of the developed media. This PASTA (Statistics Board) teaching aid is specifically designed as an interactive learning medium to help students understand mathematical concepts,

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particularly statistical material on the mean and median of grouped data, thereby improving student engagement, conceptual understanding, and learning outcomes in the classroom. The results of the validation and UAT tests are also further analyzed at that stage to see the quality of the developed teaching aids. At the dissemination stage, researchers disseminate the teaching aids so that they reach a wider audience.

3. RESULT AND DISCUSSION

Define Stage

This research begins with the define stage. In this stage, the researcher analyzed the problem and identified students' needs related to mathematics learning, particularly in statistics. Based on the literature review, students struggled to understand the meaning and use of complex statistical formulas for grouped data, such as the mean and median (Nurfadilah et al., 2026; Suliani & Saputri, 2021; Wardani et al., 2024). Furthermore, students tended to rely solely on memorizing formulas to solve statistical problems, a practice that even occurred among university students (Hendrawansyah & Saputra, 2026; Rosyidah & Mustika, 2021; Sari & Bernard, 2020). Based on other findings, it was revealed that one external factor contributing to students' difficulties in learning statistics is the limited use of interactive media and the perceived difficulty of visualizing statistical material, especially when applied to real-life situations (Nurfadilah et al., 2026). This suggests the need for meaningful learning in statistics. Therefore, if a student ever forgets a complete formula in statistics material, they will likely have difficulty recalling it because the statistical material lacks meaning.

The meaningfulness of learning is also related to the learning environment. A relatively rigid mathematics learning environment is one factor that influences student learning outcomes, characterized by teacher-dominated instruction, in which the learning process begins with the presentation of material, followed by example problems, and ends with practice problems (Sari & Putri, 2024). This technique is indeed quite effective in enabling students to solve math problems procedurally, as they tend to rely on the teacher's examples as a reference when working on practice problems (Wardani et al., 2024). However, it is undeniable that students often experience difficulties when presented with problems that differ from the examples. Not only the learning environment but also the mathematical material, with its complex formulas, often creates discomfort for students (Fitriyanti et al., 2021). Yet, the most crucial factor that determines students' initial attitudes toward learning is their interest in participating (Nugroho et al., 2020).

One factor that can increase student interest in learning is how teachers appropriately package learning. The use of learning media is one alternative solution (Hakim et al., 2020). However, the use of learning media for statistics remains limited and infrequent (Hakim et al., 2020). Statistics learning also tends to be limited to procedural and calculation exercises (Wirayuda et al., 2025). Therefore, learning media such as teaching aids are needed, specifically developed to help students understand statistical concepts concretely, so that students not only learn but also experience learning in a fun way. These teaching aids are intended to facilitate the explanation and understanding of a concept. The learning media developed in this research can be used to demonstrate the statistical concepts of mean and median using grouped data. This learning media resembles a board, hence the name "PASTA," which stands for Papam Statistik or Statistics Board.

Design Stage

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In the design stage, researchers adapt the design of the teaching aids to the results of the student needs analysis in the define stage (Aisyah et al., 2024; Lubis et al., 2021; Mahmud et al., 2019). Researchers determine how the learning media, in the form of statistical teaching aids, will be developed. These activities include selecting appropriate materials and tools, creating an initial design for the teaching aids, compiling statistical materials, and developing plans for how the material will be demonstrated through the teaching aids, and developing Expert Validation Sheets and User Acceptance Tests (UAT).

Essentially, teaching aid design should emphasize practicality and effectiveness (Nurhayati, 2023). Designing teaching aids is also not limited to the two-dimensional image form but also encompasses their format, structure, and content (Aisyah et al., 2024; Lubis et al., 2021; Mahmud et al., 2019). In terms of format, based on several considerations, particularly regarding durability, safety, aesthetic value, and economic value, the researchers chose plywood, clear acrylic, balls, and whiteboards as the main materials for making the media. In detail, the tools used by the researchers in developing "PASTA" include: (1) acrylic cutter, (2) sandpaper, (3) cutter, (4) paint brush, (5) acrylic cutter, (6) saw, (7) whiteboard marker, (8) whiteboard marker eraser, and (9) measuring tape. The materials used by the researchers include: (1) plywood, (2) clear acrylic, (3) balls, (4) whiteboard, (5) glue, (6) black paint, (7) nails, and (8) stickers.

Structurally, the teaching aids developed by the researchers are composed of a ball track, a ball storage area, and a support for the falling balls. The ball track is composed of plywood, clear acrylic, and a whiteboard. Plywood is used to create the back (background) of the ball track, the background support for the ball track, and 18 ball track dividers, resulting in 17 ball tracks. Clear acrylic was used to create the front of the ball track, allowing the number of balls placed in the track to be observed and counted from the front. A whiteboard was attached to the front of the track, which was not yet covered with clear acrylic, which would later be used to write the class for grouped data. The ball storage area, made of plywood, was used to store the balls, whiteboard markers, and whiteboard marker erasers. A ball drop holder was stored at the bottom of the track. After the user completed the grouped data mean or median problem, the holder could be pulled from the right, allowing the balls inserted during the problem to exit the track.

The design of the teaching aids needed to be aligned with the learning objectives to ensure they effectively supported the learning of the concepts of the mean and median for grouped data (Mahmud et al., 2019; Nurhayati, 2023). Therefore, in terms of content, the researchers also compiled statistical materials to be developed into learning media, covering the definitions of statistics, the mean and median, and the formulas for calculating the mean and median of grouped data. To solve the mean or median problem for grouped data, the formula uses the frequency (f_i) and the class midpoint (x_i). In this study, frequency (f_i) is defined as the number of ball paths per class, and the class midpoint (x_i) is defined as the number of balls in each path within that class. Therefore, the meaning of $f_i x_i$ in the grouped data mean formula is the total number of balls in a class, obtained by multiplying the number of ball paths by the number of balls in each path. In detail, the demonstration of the mean and median of grouped data will be presented at the development stage.

Furthermore, to ensure that the developed teaching aids are properly validated by experts and meet user needs, validation instruments and a User Acceptance Test (UAT) are also developed. Aspects are assessed in the expert validation sheet, and the User Acceptance Test (UAT), and the results are presented in the next stage.

Develop **Stage**

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In the develop stage, researchers developed PASTA teaching aids according to the design from the previous stage, conducted expert validation, and conducted limited trials (Lubis et al., 2021; Mahmud et al., 2019; Mahyuddin et al., 2024). Documentation of the teaching aid creation process is presented in Figure 2 below.

Figure 2. PASTA Teaching Aid Development Documentation

Based on Figure 2, the researchers began developing the teaching aid according to the predetermined design. Plywood and clear acrylic were the primary materials used first. After the development process, the researchers created a statistical teaching aid, which they named PASTA (Statistics Board). The front view of the PASTA teaching aid is shown in Figure 3 below.

Figure 3. Front View of the PASTA Teaching Aid

Figure 3 shows that the ball paths are separated by partitions, while the whiteboard serves as a writing surface for the class for grouped data. The rear view of the PASTA teaching aid is shown in Figure 4 below.

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Figure 4. Ball Storage

Figure 4 shows two sections separated by a partition. The left section is for whiteboard markers and erasers, and the right section is for balls.

Based on the researchers' teaching aid, the following describes the procedures for using PASTA.

1. Steps for Finding the Mean (Average) of Grouped Data
   a. Take the example of grouped data.
   b. Determine the number of ball paths to be used. The number of ball paths is adjusted based on the frequency value f_i for each interval class.
   c. Write the interval classes on the whiteboard according to the number of ball paths determined in step b.
   d. Determine the midpoint of each interval class, x_i.
   e. Take the balls from the storage area and insert x_i balls into each interval class on each ball path determined in step b.
   f. Count the total number of balls in all ball paths, $\sum f_i x_i$.
   g. Calculate the total number of ball paths, $\sum f_i$.
   h. The mean is obtained by dividing the total number of balls in all paths by the total number of ball paths, $\bar{x} = \frac{\sum f_i x_i}{\sum f_i}$.
2. Steps to Find the Median (Middle Value) for Grouped Data
   a. Take the example of grouped data.
   b. Determine the number of ball paths to be used. The number of ball paths is adjusted according to the frequency value, f_i, for each interval class.
   c. Write the interval classes on the whiteboard according to the number of ball paths determined in step b.
   d. Calculate the number of ball paths used, i.e., n, then divide by 2 to find the middle value, which is located on the middle ball path, i.e., $\frac{n}{2}$. The class containing the middle value is called the median class.
   e. Calculate the total number of ball paths from the first interval class to the median class, which is the cumulative frequency before the median class, i.e., F.
   f. Subtract the result of step d from step e, i.e., $\left(\frac{n}{2} - F\right)$. This is intended to calculate the remaining paths in the median class.
   g. Calculate the number of ball paths in the median class, i.e., f.
   h. Divide the result of step f by step g, i.e., $\left[\frac{\frac{n}{2}-F}{f}\right]$. This is intended to calculate the proportion of middle value positions in the median class.
   i. Calculate the length of the interval class, i.e., p.

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j. Multiply the result of step h by step i. This is intended to find the "distance" from the lower edge to the median position.
k. Calculate the lower edge of the median class, i.e., the lower limit of the median class minus 0.5, i.e., T_b.
l. Add the results of step j and step k to obtain the median value, i.e., $M_e = T_b + p\left[\frac{\frac{n}{2}-F}{f}\right]$.

At this stage, the researchers requested validation from experts, namely Mathematics Education lecturers and Mathematics teachers. The validation results for each assessment aspect are presented in Table 1 below.

Table 1. Expert Validation Results

Aspect	Percentage of Answers Based on Score				
	1	**2**	**3**	**4**	**5**
Content Suitability Aspect Statements 1-4 dan 9	0%	0%	0%	40%	60%
Pedagogical Aspect Statements 5-7 and 10-11	0%	0%	0%	30%	70%
Media Quality Aspect Statements 8 and 12-15	0%	0%	0%	50%	50%
Display Design and Ease of Use Aspect Statements 16-18	0%	0%	0%	50%	50%

Based on the expert validation results in Table 1, the scores for each statement were 4 and 5; thus, the PASTA teaching aid was deemed suitable for learning.

Next, a trial of the PASTA teaching aid was conducted at a Mathematics Learning Media Exhibition to introduce the tool and demonstrate its use. This activity was conducted with students of the Mathematics Education Study Program as users, accompanied by a User Acceptance Test (UAT). The UAT form contained 15 statements with answer options ranging from 1 (strongly disagree) to 5 (strongly agree). The UAT results for each assessment aspect are presented in Table 2 below.

Table 2. User Acceptance Test (UAT) Results

Aspect	Percentage of Answers Based on Score				
	1	**2**	**3**	**4**	**5**
Usability Aspect Statements 1-3	0%	0%	6,25%	46,875%	46,875%
Appearance and Design Aspect Statements 4-5	0%	0%	9,09%	50%	40,91%
Functionality Aspect Statements 6-9	0%	2,32%	0%	27,9%	69,78%
Suitability Aspect Statements 10-12	0%	3,03%	3,03%	18,18%	75,76%
User Satisfaction Aspect Statements 13-15	0%	6,06%	3,03%	48,485%	42,425%

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Based on Table 2, regarding the results of the UAT administered to users, the majority of users scored 4, indicating agreement, and 5, indicating strong agreement, on all statements, reaching over 90%. Consistent with this, other research findings indicate that a positive response indicates good user acceptance, indicating the success of a teaching aid in learning (Tin et al., 2024). This indicates that the PASTA visual aid generally received very good user acceptance. However, some respondents scored 2 and 3 across the five assessment aspects. This remains a key evaluation point for researchers to ensure optimal dissemination.

In general, the visual aid was rated very good for usability. Most users agreed that the visual aid was easy to use without significant assistance. The user manual was also deemed clear and easy to understand, helping users demonstrate statistical material using the PASTA visual aid. Users also felt they could operate the visual aid smoothly without encountering significant difficulties. This usability aspect was included in the UAT, with the hope that the use of teaching aids would reduce student frustration during the learning process (Putra et al., 2024).

In general, the PASTA teaching aids were also rated very good in terms of appearance and design. The visuals were deemed attractive, attracting users' attention. The size, shape, color, and components of the teaching aids were deemed well-suited and comfortable for learning. This is positive because, according to research, appearance and design can directly increase student engagement in the learning process (Dinç et al., 2023; Shangguan et al., 2020; Ullah & Anwar, 2020).

The PASTA teaching aids were also rated very good for usability. This usability aspect assesses the alignment of teaching aid development with user needs, ensuring that the teaching aid's functions and features provide added value for users (Kusmanto et al., 2025). Based on the UAT results, the PASTA teaching aids were deemed to increase students' interest in learning. Users also assessed that the visual aids helped them better understand statistical concepts, particularly the mean and median of grouped data. These visual aids also facilitated learning, making the learning experience more effective. This aligns with user responses to other statements that the PASTA visual aids effectively supported learning activities.

From a suitability-for-needs perspective, the visual aids were also deemed appropriate for learning needs, particularly for statistical materials on grouped data, which students often find complex. The material presented through the visual aids was also deemed appropriate for learning objectives. Alignment with the desired learning objectives is essential for effective learning of the mean and median of grouped data (Mahmud et al., 2019; Nurhayati, 2023).

In line with other aspects, regarding user satisfaction, the majority of respondents stated that the visual aids were suitable for classroom learning activities. Users also expressed high satisfaction with the visual aids. Most users were willing to reuse the visual aids in their lessons. Furthermore, they were also willing to recommend the visual aids to others. This user satisfaction is, of course, also supported by the user-friendliness aspect (Putra et al., 2024), the first aspect presented in UAT, and is one of the important aspects in the use of learning aids.

From a pedagogical perspective, the effectiveness of the PASTA visual aids can be explained through constructivist learning theory, which emphasizes active learning through hands-on experience (Almulla, 2023). According to Piaget, learners actively construct knowledge through interactions with their environment, while Bruner argues that learning is more effective when students progress from concrete experiences (enactive representation) to visual representations (iconic representation) before reaching abstract mathematical symbols (symbolic representation) (Chand, 2023). Therefore, the PASTA visual aids provide students

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with concrete and visual learning experiences that facilitate their understanding of statistical concepts.

Disseminate Stage

The implementation of this stage is still relatively limited. Currently, the PASTA teaching aids are disseminated as video tutorials on their use, broadcast on the social media platform YouTube. PASTA teaching aids are also produced through lectures, so they are usually displayed in the Mathematics Learning Media Laboratory, which is frequently visited by students both internally and externally. However, these teaching aids can also be distributed to schools so that students and teachers can benefit from the development of PASTA. At this stage, user feedback is also needed for further evaluation and improvement (Kepper et al., 2024). It is hoped that at this stage, the evaluation process of teaching aids will continue to improve the quality of the PASTA teaching aids being developed, thereby further improving learning outcomes after their implementation.

4. CONCLUSION

PASTA (Statistics Board) is a learning tool specifically designed to facilitate student learning, particularly in overcoming common difficulties in statistics. This teaching aid focuses on helping students understand and calculate measures of central tendency, such as the mean and median, particularly for grouped data, which students generally find more complex. PASTA allows abstract concepts to be presented more concretely and visually, making them easier to understand. Furthermore, using PASTA in learning offers other benefits, including creating a more engaging, interactive, and enjoyable mathematics learning environment. Students not only passively receive material but also actively engage in the learning process through the tool.

Expert validation results indicate that the PASTA teaching aid is suitable for learning. The UAT results demonstrate a predominance of positive responses from users, demonstrating the tool's success in learning. Therefore, PASTA can be used as an effective mathematics learning tool, particularly in helping students understand statistical concepts more deeply and improving their motivation and learning outcomes. To enrich the findings of this study, further research can examine the dissemination of the PASTA teaching aid in greater depth. Other researchers can also use similar media with their own innovations to discover that there are still many statistical teaching aids that can be developed to improve students' ability to understand statistical concepts.

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